

Volume 21

Study G-II-A

STATE OF ALASKA

Jay S. Hammond, Governor

Annual Performance Report for

COHO SALMON STUDIES IN
THE RESURRECTION BAY AREA

by

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RESEARCH PROJECT SEGMENT

State: ALASKA Name: Sport Fish Investigations
of Alaska

Project No.: F-9-12

Study No.: G-II Study Title: SPORT FISH STUDIES

Job No.: G-II-A Job Title: Coho Salmon Studies in
the Resurrection Bay Area

Period Covered: July 1, 1979 to June 30, 1980.

ABSTRACT

Bear Lake was restocked with 225,500 age 0.0 coho salmon, Oncorhynchus kisutch (Walbaum), fingerlings on May 24, 1979 to maintain smolt production.

The Bear Creek weir downstream migrant trap was operated continuously from May 10 through September 25. A total of 105,316 age 1.0 and 2.0 coho smolts were enumerated. Yearling (age 1.0) smolt survival from the 1978 Bear Lake fingerling plant was 43.0 percent, with a ratio of 5.9:1.0 smolt-to-fingerling biomass (kilogram) yield.

Bear Lake's smolt out-migration timing and abundance, age and size compositions, and condition factors are presented. Bear Creek water temperatures and stream flows corresponding to migration peaks and durations are also given. Optimum smolt production at current stocking densities, and the possibility of improving Bear Lake's carrying capacity via artificial fertilization, are discussed.

The Resurrection Bay creel census (July 8-September 9) indicated an estimated 17,785 coho were harvested by 24,651 man-days of sport effort. The mean seasonal catch per angler hour was 0.131 coho. Enhanced adult coho production contributed an estimated 22.8 percent to the sport harvest. Most adults (66.4 percent) survived from 97,659 Bear Lake smolts (25.0 percent marked LV, RV) and 28,574 age 1.0 (1976 brood, Seward Lagoon origin) Ad-CWT marked hatchery smolts released in lower Bear Creek in May, 1978. The remaining 33.6 percent returned from 125,979 smolts (31.1 percent Ad-CWT) and 53,555 smolts (47.5 percent Ad-CWT) stocked in Seward Lagoon and Grouse Lake in late May-early June, 1978.

The Bear Creek weir upstream migrant trap was operated continuously from May 10 through November 15. The coho upstream migration to the trap extended from August 11 to November 14, and consisted of 2,493 adults and 23 jacks. Adults were comprised of 221 Ad-CWT, 10 RV, 3 LV and 2,259 unmarked coho. The 23 jacks resulted from 94,014 Bear Lake smolts and 29,200 age 1.0 (1977 brood, Bear Lake origin) hatchery smolts released unmarked in Bear Creek in 1979.

Total smolt-to-adult survivals per release lot were 4.0 percent (Bear Lake), 4.7 percent (Bear Creek), 1.5 percent (Grouse Lake) and 0.9 percent (Seward) Lagoon). The very low Seward Lagoon smolt survival may have resulted from critically overstocking the 4.13 hectare lagoon. Total survival of Bear Lake smolt out-migrations (1973-1978), Bear Creek (1969-1978), Seward Lagoon (1968-1978) and Grouse Lake (1976-1978) hatchery smolt releases are summarized.

The catch-to-escapement ratio of marked Bear Lake coho was 0.72:1. The adult male to female sex ratio was 1.5:1 in the Bear Creek escapement. An estimated 730,800 fertilized eggs were artificially spawned from 190 females and 40 males from the Bear Lake and Seward Lagoon returns.

Data on the timing and abundance of other fish species ascending and descending Bear Creek to the weir are presented. Minimum wild coho escapements in seven local index streams are reviewed.

BACKGROUND

Wild coho salmon production in Resurrection Bay is believed to be directly affected by the extreme fluctuations in stream flows and water temperatures characteristic of its drainage streams. Since 1961, the Resurrection Bay coho recreational fishery has become the largest marine sport fishery for this species in Alaska. Therefore, it became imperative to stabilize or improve Resurrection Bay coho production to satisfy growing angler demand in the fishery. Table 1 lists the anadromous fish species indigenous to Resurrection Bay and Figure 1 shows its drainage tributaries.

Bear Lake, located seven miles north of Seward, was chosen for coho rearing because it is the largest (180 hectares or 445 acres) stable body of clear fresh water in the Resurrection River drainage, and is accessible by road. It was determined after a survey in 1962 that Bear Lake should be rehabilitated with rotenone to eradicate all predator-and competitor-fish species inhabiting the lake. Without predation and interspecific competition, it was believed Bear Lake could then produce a high sustained smolt yield from annual coho fingerling plants.

FIGURE 1.

RESURRECTION BAY WATERSHED

- | | |
|------------------------|--------------------|
| 1. Salmon Creek | 2. Bear Creek |
| 3. Grouse Creek | 4. Bear Creek Weir |
| 5. Airport Creek | 6. Jap Creek |
| 7. Dairy Creek | 8. Seward Highway |
| 9. Grouse Lake | 10. Seward |
| 11. Resurrection River | |
| 12. Mayor Creek | |
| 13. Small Boat Harbor | |
| 14. Seward Lagoon | |
| 15. Clear Creek | |
| 16. Box Canyon Creek | |

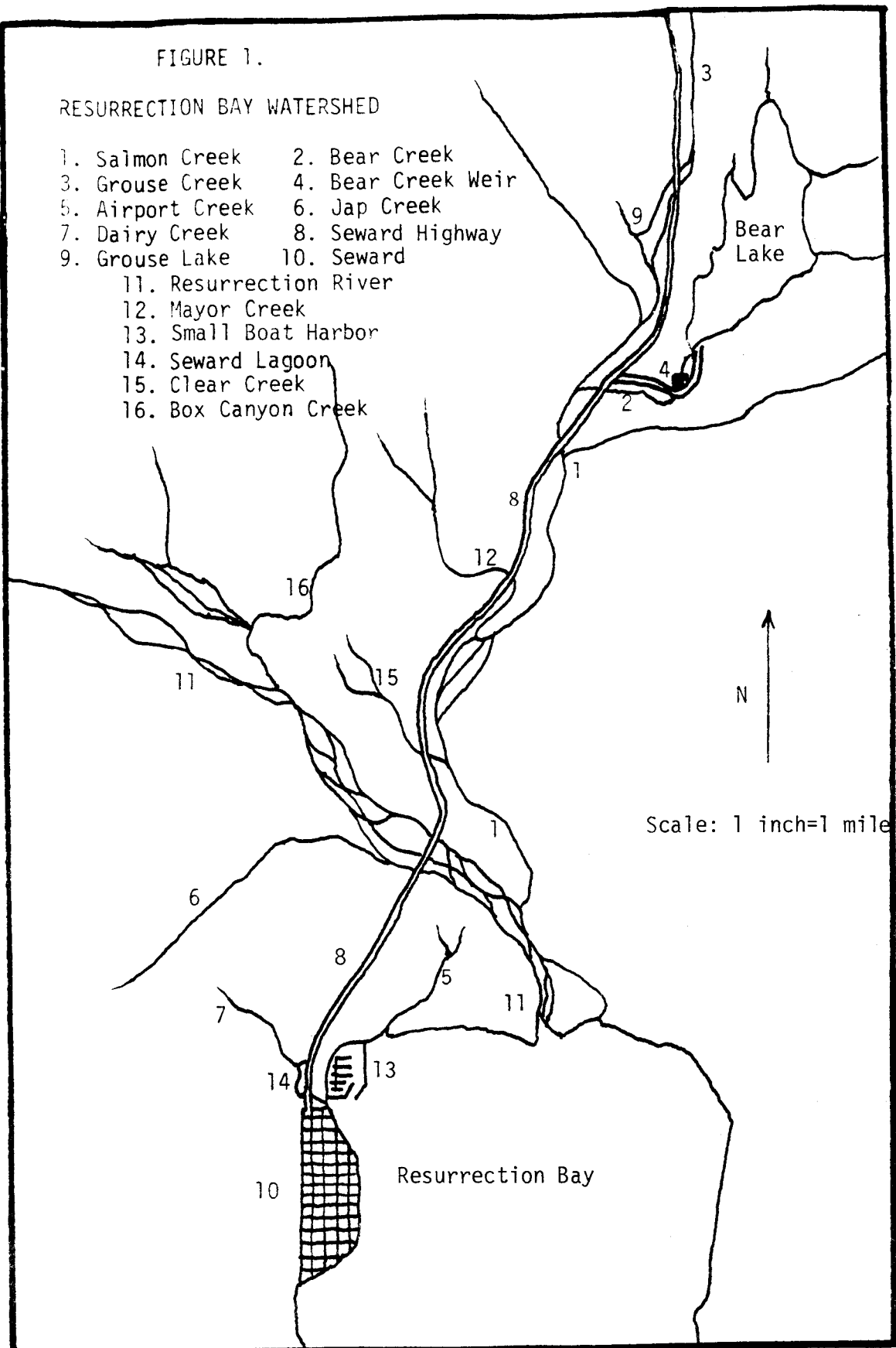


Table 1. Checklist of Fish Species Present in the Resurrection Bay
Drainage.

Common Name	Scientific Name and Author
Dolly Varden	<i>Salvelinus malma</i> (Walbaum)
Rainbow-steelhead trout	<i>Salmo gairdneri</i> Richardson
Sockeye salmon	<i>Oncorhynchus nerka</i> (Walbaum)
Coho salmon	<i>Oncorhynchus kisutch</i> (Walbaum)
Chum salmon	<i>Oncorhynchus keta</i> (Walbaum)
Chinook salmon	<i>Oncorhynchus tshawytscha</i> (Walbaum)
Pink salmon	<i>Oncorhynchus gorbuscha</i> (Walbaum)
Threespine stickleback	<i>Gasterosteus aculeatus</i> Linnaeus

Pre-rehabilitation species abundances were measured by a temporary weir situated at the Bear Creek-Salmon Creek confluence from 1961 to 1964. Upstream migrations averaged 921 adult coho salmon, (1961-1964); 4,801 adult sockeye salmon, (1961-1965); and 10,543 Dolly Varden, (1961-1962). Downstream migrations in 1962-1963 averaged 7,933 coho smolts, 51,232 sockeye smolts, and 17,838 Dolly Varden. Though threespine stickleback migrations were not estimated at the weir, beach seine sampling indicated that this species was abundant in Bear Lake.

Bear Lake was rehabilitated with powdered rotenone at 1.0 mg/l (5% level) on August 26, 1963. A 1.5-meter (5 foot) high dam was erected at the outlet to contain the treated water until detoxification and to prevent subsequent immigration of undesirable species. Bear Lake was detoxified by October 17, 52 days after the water was treated, and received its first annual fingerling plant that winter through the ice. All fingerling plants, except the 1966 release, were fin-marked at Fire Lake Hatchery to facilitate smolt survival evaluation.

The Good Friday earthquake on March 27, 1964 destroyed the outlet dam, which washed out completely on May 25. This allowed unobstructed entry of all fish ascending Bear Creek into Bear Lake until June 15, when the barrier was repaired. A permanent weir was constructed 533.4 meters (1,750 feet) downstream from the outlet to assess Bear Lake's coho smolt production and returning adult migrations.

Bear Lake became reinfested with threespine sticklebacks. It is not known whether this was due to insufficient rotenone treatment or the destruction of the outlet barrier. Also, Dolly Varden were able to negotiate the weir during fall flood levels and immigrate into the lake on most years.

Before rapid expansion of the stickleback population occurred, Bear Lake's coho and sockeye smolt production increased several fold as a result of favorable rearing conditions from 1964 to 1966. Coho smolt biomass (weight) production attained 4.2 kilograms for each kilogram of fingerlings planted in 1964. Smolt age structures changed from predominantly age 2.0 to age 1.0 with growth exceeding that of former age 2.0 smolts. Smolt survival from stocked coho fingerlings reached 43.5% of the 1964 and 48.1% of the 1965 plants. Had sufficient coho fingerlings been available for stocking Bear Lake at desired densities in 1963-1965, coho smolt production would have been considerably higher. Bear Lake's enhanced smolt production increased pre-rehabilitation abundances of adult sockeye by 11 times and coho by 3.5 fold.

Bear Lake's high smolt production was short lived, however, due to the stickleback's rapid takeover of the rearing environment beginning in 1967. Smolt age structures reverted to age 2.0 dominance, growth rates declined, and fingerling-to-smolt survivals lowered. Coho fingerling plants were terminated after 1967 because smolt production was obviously dropping below

pre-rehabilitation levels. By 1968, threespine sticklebacks had already reached pre-rehabilitation abundance in the lake.

In 1969, it was decided to rehabilitate Bear Lake again. Stickleback population sampling in 1970 showed that this species inhabited all areas and depths in Bear Lake. The Bear Creek weir was reconstructed in 1969 and was made entirely "fish-tight" by removing the sloping upstream fence and adding three permanent, perforated plate screens above the upstream migrant trap.

Bear Lake was rehabilitated again in 1971, and lake treatment was conducted essentially the same as in 1963 except that 100% emulsified instead of powdered rotenone was used. Overall treatment level was 1.6 mg/l rotenone at 5% concentration. Caged live fish suspended from surface to bottom, 12 to 18 meters (40 to 60 feet), were all dead within 1 week. Population sampling 2 days following rehabilitation showed that threespine sticklebacks comprised 98.8% of the total sample ($n = 9,065$) collected randomly on and around Bear Lake. From this it was concluded that obtaining less than total lake rehabilitation in 1963 ultimately resulted in lower-than-normal salmon production in Bear Lake over the long term.

Bear Lake remained toxic through the winter of 1971-1972, and was finally detoxified shortly after spring overturn. Annual coho fingerling plants in Bear Lake resumed in June 1972 at desired stocking densities. Resultant smolts were enumerated, sampled weekly for age and size composition as well as condition factor, and fin-marked for recognition in the fishery before being released at Bear Creek weir. No threespine sticklebacks have been detected in Bear Lake during fall population sampling of juvenile coho by electrofishing or at Bear Creek weir since the 1971 rehabilitation.

Bear Lake was stocked from 1972-1975 at densities ranging from 2,461 to 2,503 fingerlings per surface hectare. The cumulative effect in just 3 years resulted in critically overstocking Bear Lake's coho rearing habitat.

Intense intraspecific competition among fingerlings evidently depressed growth rates, lowered survivals and extended rearing duration to smoltification. Mean seasonal condition factors of all smolts sampled each year were observed to drop from 0.98 (1973) to 0.90 (1974) and 0.89 (1975). The percentage of fingerling plants resulting in age 1.0 smolts also decreased from 17.2% (1973) to 14.5% (1974) and 3.0% (1975). Similarly, biomass ratios of age 1.0 smolts produced per fingerling release declined abruptly from 8.9:1 (1973) to 4.9:1 (1974) and 0.4:1 (1975).

Increased stress from overcrowding apparently led to greater susceptibility (lowered resistance) of rearing fingerlings to natural diseases in Bear Lake. Though the 1975 smolt out-migration (168,036 smolts) was the largest ever recorded for Bear Lake, over 91% were age 2.0 smolts in relatively poor condition. Nearly 13% of the smolt run died from eye fluke, Diplostomulum spathaceum, and fungus, Saprolegnia sp., diseases at the weir. Only 1.1% of the 143,589 smolts released in 1975 survived to return as adults in 1976.

A downward adjustment in Bear Lake's fingerling stocking density was therefore clearly indicated from these findings. Bear Lake has been stocked since 1976 at only 1,247 to 1,265 per hectare, or approximately one-half previous levels, to enhance fingerling growth and survival to smolts. The following report presents the findings and discusses the results of this reduced fingerling stocking density on Bear Lake's coho salmon production.

RECOMMENDATIONS

1. The present objectives of the study should be retained.
2. The 1981 stocking density of coho fingerlings in Bear Lake should be adjusted according to emigrating smolt and residual fingerling abundance, age composition and condition factor in 1980.
3. Baseline data on Bear Lake's physical, chemical and biological parameters should continue to be collected preliminary to artificial fertilization experiments.

OBJECTIVES

1. To determine the distribution, abundance, and timing of out-migrant and adult coho salmon in the Resurrection Bay area.
2. To determine the age and size composition of out-migrant and adult coho salmon populations in selected tributaries.
3. To determine the sport harvest and fishing mortality of coho salmon in Resurrection Bay.
4. To determine the methods and means of increasing or extending the freshwater spawning and rearing areas of the watershed, and mitigating freshwater mortality.
5. To provide recommendations for the management of coho salmon in these waters and direct the course of future studies.

TECHNIQUES USED

The timing and abundance of sockeye and coho salmon smolts emigrating from Bear Lake downstream to Bear Creek weir were determined by enumerating these fish at the downstream migrant trap. Weir location and description of the downstream trapping facilities were described by Logan (1969). The timing and abundance of adult sockeye and coho salmon were measured by enumerating these fish at the weir's upstream migrant trap. Adult trapping

facilities, rebuilt in 1969 and modified in 1970, were described by McHenry (1971). Bear Creek water temperatures and stream flows were recorded daily at the weir to subsequently correlate these physical parameters with the onset, peak, and termination of migrations.

Age and size composition of Bear Lake sockeye and coho smolt populations were determined by weekly sampling at the weir. Age compositions of Bear Lake sockeye and coho smolt populations were determined by examining representative scale impressions on 0.02-inch cellulose acetate with a Bruning model 200 microfiche. Smolt abundance per age group was calculated by extrapolating the age composition, as determined in weekly scale sample analysis, to the total number of smolts emigrating during those weekly periods. Age composition of the Resurrection Bay wild coho return was not sampled because these fish could not be differentiated from adults surviving from the unmarked components of hatchery smolt releases in 1978. Age composition of the Bear Lake unmarked coho return was not sampled because adult coho returning from natural smolt production in lower Bear Creek were indistinguishable from Bear Lake smolts released unmarked in 1977. Age and size composition of the Bear Lake adult sockeye return was not sampled due to the scarcity of fish. Size composition of Bear Lake's coho escapement was determined by representatively sampling the migration for fork length, weight and sex. All fish sampled were anesthetized in a 50 mg/l solution of MS-222 (Tricaine methanesulfonate) to facilitate handling and minimize mortality.

The Resurrection Bay coho sport harvest and angler effort (man-days) were measured by a stratified, random creel census conducted at the Seward small boat harbor. Sampling design and interview methods were nearly identical to that described by Logan (1966). The average number and percentage of sport fishing boats returning to the Seward small boat harbor were determined for each of three 3.5-hour sampling periods extending from 11:30 a.m. to 10:00 p.m. Returning boats were not sampled from 8:00 a.m. to 11:30 a.m. because only 11.6% of the weekend and 14.3% of the weekday sport craft returned during this period in the 3 years sampled (1964-1966). The mean number of boats returning during this morning period was extrapolated using the above percentages. These estimates were then added to those determined for the three periods sampled to estimate total daily boats. Total sport fishing effort and harvest were estimated for the season by multiplying weekly means (anglers/boat and salmon/boat) times total returning boats for all weekends and weekdays included in the creel census period. Fishing mortality and catch-to-escapement ratio of unmarked and marked (fin-clipped) adult coho were determined by extrapolating the marked coho catch observed during creel census and by recording marked versus unmarked coho in the Bear Lake, Grouse Creek, and Seward Lagoon spawning escapements. Coho taken in the shore fishery after the boat creel census terminated were considered "escapement" for the Resurrection Bay catch-to-escapement ratio determination.

An index to Resurrection Bay coho escapement abundance was measured by conducting weekly foot surveys on seven local index streams throughout immigration until peak of spawning terminated. All carcasses were examined for clipped fins and sex determination, then mutilated to preclude re-counting on subsequent surveys.

Evaluation of Bear Lake's rehabilitated rearing environment was continued by measuring the abundance, growth and condition of smolts surviving from the 1977 and 1978 coho fingerling plants. Smolt biomass (kilograms) production was calculated by multiplying the seasonal mean smolt weight (grams) per age group by the total number of smolts emigrating in each age group in 1979.

FINDINGS

Results

The findings presented are the result of the 1979-1980 research segment of the project. For a description of the Resurrection Bay drainage and past information collected on the project, see Logan (1962-1969) and McHenry (1970-1979).

Bear Lake Coho Smolt Migration:

The Bear Creek weir downstream migrant trap was operated continuously from May 10 through September 25 when the trap was removed due to stream flows exceeding 125 cfs and cessation of the Bear Lake smolt emigration. Abundance and timing of the coho salmon smolt out-migration are shown in Table 2. Fingerlings emigrating Bear Lake were retained above the weir.

The out-migration to the downstream trap totaled 105,316 smolts. Trap mortality claimed 840 smolts (0.8% of the out-migration). A total of 104,476 live smolts were released downstream. A predetermined 10% of the out-migration received a left ventral (LV) fin-clip for recognition in the 1980 Resurrection Bay sport fishery and Bear Lake spawning escapement. Table 3 shows the number and percentage of smolts marked and sampled in each weekly period.

Smolt emigration began on May 10, peaked (50% of out-migration) by June 13, and terminated September 24. The highest daily count occurred on June 14 when 7,061 (6.7% of the total run) were enumerated from the trap.

Mean stream temperatures when smolt emigration began, peaked, and terminated were 2.2°C (36°F), 11.9°C (53.5°F), and 10.0°C (50°F), respectively. Bear Creek stream flows ranged from 12 to 128 cfs during this period.

Table 2. Bear Lake Coho Salmon Smolts Enumerated at Bear Creek Weir by Weekly Periods, 1979.

Weekly Periods	Number of Smolts		Total
	Live	Dead	
May 6 - May 12	6		6
May 13 - May 19	6	2	8
May 20 - May 26	11		11
May 27 - June 2	5,264	3	5,267
June 3 - June 9	30,886	1	30,887
June 10 - June 16	35,841	49	35,890
June 17 - June 23	22,608	4	22,612
June 24 - June 30	8,618	776	9,394
July 1 - July 7	704		704
July 8 - July 14	105	1	106
July 15 - July 21	233	1	234
July 22 - July 28	59		59
July 29 - August 4	2		2
August 5 - August 11	40		40
August 12 - August 18	32	3	35
August 19 - August 25			
August 26 - September 1			
September 2 - September 8			
September 9 - September 15	11		11
September 16 - September 22	23		23
September 23 - September 29	<u>27</u>	<u>—</u>	<u>27</u>
Total	104,476	840	105,316

The smolt out-migration was comprised of 92.2% (97,144) age 1.0 and 7.8% (8,172) age 2.0 smolts. No age 3.0 smolts were detected in the sample. Tables 4 and 5 present the mean fork length, weight, condition factor and relative percentage of age 1.0 and 2.0 smolts in the weekly samples. Table 6 shows the weekly and seasonal smolt abundance per age group. An overall 1.0% (1,058 smolts) was representatively sampled during emigration (Table 3). An estimated 96,327 age 1.0 and 8,149 age 2.0 smolts were released downstream.

Age 1.0 and 2.0 smolt migrations both peaked during the week of June 10-16 when Bear Creek water temperatures averaged 11.1°C (51.9°F). Approximately 68% of the Bear Lake smolt out-migration had migrated to the weir by the end of the first week that Bear Creek mean water temperature exceeded 10°C (50°F). About 65% (+3%) of Bear Lake smolt migrations since 1973 have been processed through the downstream trap during this period (McHenry, 1979). Bear Lake's total coho smolt out-migration, therefore, can be readily predicted on any given year by estimating that 65% of the smolt population has reached the weir by the end of that week.

Age 3.0 smolts were considered nonexistent in the 1979 smolt out-migration. These fish would have been produced from the 224,600 age 0.0 fingerlings stocked in Bear Lake in 1976. Therefore, total smolt survival of that plant remains at 29.5%. Age composition of Bear Lake's fifth smolt production cycle since the 1971 rehabilitation project was 75.1% age 1.0 and 24.9% age 2.0. Bear Lake coho fingerling plants since 1975 are summarized in Table 7, and smolt production since 1976 is presented in Table 8.

The 8,172 age 2.0 smolts were produced from 227,700 age 0.0 fingerlings stocked in 1977. With the 81,014 age 1.0 smolts which emigrated in 1978, 39.2% of that plant has survived to smolts thus far. Though electro-sampling of Bear Lake's residual coho population was not conducted in the fall of 1979, it is believed that few age 2.0 fingerlings remain, according to the small magnitude of the above age 2.0 smolt migration. Therefore, age 3.0 smolt production from this plant should be meager, if any. Excepting the latter, age composition of Bear Lake's sixth smolt production cycle was 90.8% age 1.0 and 9.2% age 2.0.

The 97,144 age 1.0 smolts resulted from the seventh annual Bear Lake plant of 225,800 age 0.0 fingerlings in 1978. This was the third fingerling release made since 1972 at reduced stocking density. Fingerling-to-smolt survival of this age group was 43.0%, which is the highest percentage realized of any Bear Lake fingerling plant resulting in yearling smolts. Total fingerling-to-smolt survival of this plant may reach 50%.

Age 1.0 smolts not only were the most abundant but also the second largest fish in their age group to emigrate Bear Lake in the project's 17-year history. They resulted from fingerlings averaging 743/kg (337/lb), or approximately 46 mm in fork length when stocked (Table 7).

Table 3. Bear Lake Coho Salmon Smolts Marked and Sampled at Bear Creek Weir by Weekly Periods, 1979.

Weekly Periods	Number of Live Smolts	Number Smolts Fin Clipped	Percent of Weekly Migration	Number Smolts Sampled	Percent of Weekly Migration*
May 6 - 12	6				
May 13 - 19	6				
May 20 - 26	11	1	9.1	8	72.7
May 27 - June 2	5,264	498	9.5	50	0.9
June 3 - 9	30,886	1,953	6.3	150	0.5
June 10 - 16	35,841	2,868	8.0	450	1.3
June 17 - 23	22,608	3,272	14.5	250	1.1
June 24 - 30	8,618	1,870	21.7	150	0.2
July 1 - 7	704				
July 8 - 14	105				
July 15 - 21	233				
July 22 - 28	59				
July 29 - August 4	2				
August 5 - 11	40				
August 12 - 18	32				
August 19 - 25					
August 26 - Sept. 1					
Sept. 2 - 8					
Sept. 9 - 15	11				
Sept. 16 - 22	23				
Sept. 23 - 29	27				
Total	104,476	10,462	10.0	1,058	1.0

* Minus the 840 smolts expiring from trap mortality.

Table 4. Mean Fork Length, Weight and Condition Factor of Age 1.0 Bear Lake Coho Salmon Smolts Sampled Weekly at Bear Creek Weir, 1979.

Weekly Periods	Number of Smolts	Percent of Sample	Mean Length (mm) \pm SD	Mean Weight (g) \pm SD	Condition Factor(K) *
May 20 - 26	8	100.0	111.3 \pm 5.6	14.84 \pm 1.19	1.08
May 27 - June 2	46	92.0	113.9 \pm 7.0	14.46 \pm 2.69	0.98
June 3 - 9	135	90.0	118.4 \pm 6.1	17.08 \pm 2.42	1.03
June 10 - 16	417	92.7	120.6 \pm 3.8	18.36 \pm 2.95	1.05
June 17 - 23	234	93.6	123.8 \pm 6.3	19.72 \pm 2.88	1.04
June 24 - 30	142	94.7	125.1 \pm 7.6	20.37 \pm 3.41	1.04

* $K = \frac{W \times 10^5}{L^3}$, where W = mean weight in grams, and L = mean fork length in millimeters.

Table 5. Mean Fork Length, Weight and Condition Factor of Age 2.0 Bear Lake Coho Salmon Smolts Sampled Weekly at Bear Creek Weir, 1979.

Weekly Periods	Number of Smolts	Percent of Sample	Mean Length (mm) \pm SD	Mean Weight (g) \pm SD	Condition Factor(K)*
May 20 - 26	0				
May 27 - June 2	4	8.0	140.8 \pm 22.1	28.35 \pm 14.05	1.02
June 3 - 9	15	10.0	138.9 \pm 7.8	27.79 \pm 4.18	1.04
June 10 - 16	33	7.3	146.2 \pm 10.5	31.63 \pm 6.97	1.01
June 17 - 23	16	6.4	147.3 \pm 14.5	32.02 \pm 8.34	1.00
June 24 - 30	8	5.3	155.0 \pm 7.2	35.63 \pm 4.33	0.96

* $K = \frac{W \times 10^5}{L^3}$, where W = mean weight in grams, and L = mean fork length in millimeters.

Table 6. Relative Abundance and Timing of Age 1.0 and 2.0 Bear Lake Coho Salmon Smolts Migrating to Bear Creek Weir, 1979.

Weekly Periods	Number of Smolts**		Total
	Age 1.0	Age 2.0	
May 20 - 26*	25		25
May 27- June 2	4,846	421	5,267
June 3 - 9	27,798	3,089	30,887
June 10 - 16	33,270	2,620	35,890
June 17 - 23	21,165	1,447	22,612
June 24 - 30	8,896	498	9,394
July 1 - 7	649	55	704
July 8 - 14	98	8	106
July 15 - 21	216	18	234
July 22 - 28	54	5	59
July 29 - August 4	2		2
August 5 - 11	37	3	40
August 12 - 18	32	3	35
August 19 - 25			
August 26 - Sept. 1			
Sept. 2 - 8			
Sept. 9 - 15	10	1	11
Sept. 16 - 22	21	2	23
Sept. 23 - 29	<u>25</u>	<u>2</u>	<u>27</u>
Total	97,144	8,172	105,316
Percent	92.2	7.8	100.0

* Includes 14 smolts captured in previous two weeks. Age composition is based on May 20-26 weekly sample (100% age 1.0).

** Number of smolts per age group after June 24-30 is estimated by overall age composition determined up to that point.

Table 7. Summary of Bear Lake Coho Salmon Fingerling Plants, 1975-1979.

Brood Year	Source of Eggs	No. Fish Stocked	Weight		Size*		Density		Dates of Plants	Planting Method
			lbs	kg	No./lb	No./kg	No./acre	No./ha		
1974	Bear Lake	245,600	454	205.9	541	1,192	552	1,363	June 19	Aircraft
	Bear Lake	<u>204,400</u>	<u>455</u>	<u>206.4</u>	<u>449</u>	<u>989</u>	<u>459</u>	<u>1,135</u>	July 1	Scattered
	Total	<u>450,000</u>	<u>909</u>	<u>412.3</u>	<u>495</u>	<u>1,091</u>	<u>1,011</u>	<u>2,498</u>	1975	
1975	Bear Lake	149,800	433	196.4	346	763	337	832	June 10	Aircraft
	Bear Lake	<u>74,800</u>	<u>185</u>	<u>83.9</u>	<u>405</u>	<u>893</u>	<u>168</u>	<u>415</u>	June 14	Scattered
	Total	<u>224,600</u>	<u>618</u>	<u>280.3</u>	<u>363</u>	<u>800</u>	<u>505</u>	<u>1,247</u>	1976	
1976	Bear Lake	<u>227,700</u>	<u>780</u>	<u>353.8</u>	<u>292</u>	<u>644</u>	<u>512</u>	<u>1,264</u>	June 16	Truck-boat
									1977	Scattered
1977	Bear Lake	157,000	457	207.3	345	757	353	871	June 20	Truck-boat
		<u>68,800</u>	<u>216</u>	<u>98.0</u>	<u>320</u>	<u>705</u>	<u>154</u>	<u>382</u>	June 20	Scattered
	Total	<u>225,800</u>	<u>673</u>	<u>305.3</u>	<u>337</u>	<u>743</u>	<u>507</u>	<u>1,253</u>	1978	
1978	Bear Lake	<u>225,500</u>	<u>340</u>	<u>154.2</u>	<u>663</u>	<u>1,462</u>	<u>507</u>	<u>1,253</u>	May 24	Aircraft
									1979	Scattered

* Weighted averages.

Table 8. Summary of Bear Lake Coho Salmon Smolt Abundance and Biomass Produced Since 1976 from Annual Fingerling Plants, 1975-1978.

Year of Plant	No. of Fingerlings and Weight (kg)	Smolt Production by Year				Total Production	Survival to Smolt (%)
		1976	1977	1978	1979		
<u>1975</u>							
Number	450,000	64,083	48,393	393		112,819	25.1
Weight (kg)	412.7	915.6	1,050.6	22.5		1,988.7	
Weight Ratio		2.2:1	2.5:1	0.1:1		4.8:1	
<u>1976</u>							
Number	224,600		49,752	16,457	0	66,209	29.5
Weight (kg)	280.3		795.5	424.0		1,219.5	
Weight Ratio			2.8:1	1.5:1		4.4:1	
<u>1977</u>							
Number	227,700			81,014	8,172	89,186	39.2*
Weight (kg)	353.8			1,422.8	255.0	1,677.8	
Weight Ratio				4.0:1	0.7:1	4.7:1	
<u>1978</u>							
Number	225,800				97,144		43.0**
Weight (kg)	305.3				1,808.0		
Weight Ratio					5.9:1		

* Does not include age 3.0 smolt production.

** Includes only age 1.0 smolt production.

Age 1.0 smolts averaged 120.6 mm and 18.36 g for a condition factor (K) of 1.05 at peak of migration, June 10-16. Age 2.0 smolts averaged 146.2 mm and 31.63 g for a K = 1.01 during the same migration peak period.

Bear Lake's estimated smolt biomass in 1979 was 2,063 kg, or a 193.7 kg improvement over that yielded in 1978. Table 9 summarizes total number of smolts, estimated annual biomass and seasonal condition factor of Bear Lake smolt migrations since 1973. On the average, Bear Lake should be capable of producing at least 100,000 smolts with a condition factor K = 1.01 for a total biomass of 2,100 kg under natural conditions.

Bear Lake was restocked on May 24, 1979 with 225,500 age 0.0 coho fingerlings (1978 brood, Bear Lake origin) averaging 1,462/kg (663/lb) to maintain smolt production.

Other Species:

The total sockeye salmon smolt out-migration enumerated from the trap was 747 fish. The first smolt was captured on May 14, and the last on July 28. The highest daily count occurred on May 30 when 146 smolts (19.5% of the migration were enumerated. The majority (87.1%) emigrated between May 20 and June 23, when water temperatures ranged from 3.3°C to 14.4°C (38°F-58°F) and stream flows ranged from 14 to 29 cfs. The smolt out-migration was comprised of 31 (4.1%) age 1.0, 701 (93.9%) age 2.0, and 15 (2.0%) age 4.0 smolts. Age 4.0 smolts resulted from the 1974 Bear Lake escapement of 36 females and 24 males. Including the 6 age 1.0, 284 age 2.0, and 248 age 3.0 smolts which emigrated in 1976, 1977 and 1978, respectively, the total smolt production was 553 smolts (15.4 per female) for the third, post-rehabilitation sockeye salmon escapement into Bear Lake. No age 3.0 smolts were produced because only seven jacks comprised the 1975 escapement (Bear Lake produced no sockeye smolts in 1972-1973 due to the 1971 lake rehabilitation). Age 2.0 smolts were produced by the 271 females and 307 males that spawned in 1976. With the 11,678 age 1.0 smolts estimated in 1978, a total of 12,379 smolts (45.7 per female) have resulted from this parent brood thus far. Age 1.0 smolts resulted from 13 females and 22 males in the 1977 Bear Lake escapement. Smolt emigration peaked during May 27 through June 2 when Bear Creek stream temperature averaged 6.6°C (43.9°F). Limited population sampling (n=40) indicated that age 1.0, 2.0 and 4.0 smolts averaged 107.5, 149.3 and 277.0 mm in fork length, respectively. Condition factors were 1.07 (age 1.0 and 2.0) and 1.03 (age 4.0) at peak of migration.

A total of 109 Dolly Varden were captured in the downstream trap and released below the weir. No threespine sticklebacks were caught in the trap nor observed in Bear Lake during the field season.

Table 9. Summary of Abundance, Total Annual Biomass and Seasonal Condition Factor of Bear Lake Coho Smolt Migrations, 1973-1979.

Year	Total No. of Smolts	Condition Factor (K)	Total Biomass (kg)
1973	77,343	1.06	2,149.3
1974	72,389	0.93	1,743.2
1975	168,036	0.89	3,381.3
1976	93,311	1.07	2,016.8
1977	99,970	1.03	1,940.2
1978	97,814	0.99	1,869.3
1979	<u>105,316</u>	<u>1.05</u>	<u>2,063.0</u>
Average	102,026	1.01	2,166.2

Resurrection Bay Coho Salmon Harvest and Effort:

A stratified, random creel census to determine the Resurrection Bay coho sport harvest and effort was initiated at the Seward small boat harbor on July 8 and terminated September 9. Few coho were taken before creel census began since most sport fishing effort was directed toward the more abundant rockfish, Sebastes spp., from mid-May through early July.

The season's total harvest was an estimated 17,785 coho salmon. This estimate was extrapolated from interviews with 3,922 anglers harvesting 2,766 coho salmon during the creel census period. The peak of the harvest occurred on August 11, first day of the Seward Silver Salmon Derby, when an estimated 1,080 coho salmon (6.1% of the season's harvest) were taken. The season's total and derby harvests are summarized for 1975 through 1979 in Table 10.

Marked adult coho salmon contributed 7.7%, or an estimated 1,360 fish to the 1979 Resurrection Bay sport harvest. An additional 2,699 unmarked coho salmon, resulting from the unmarked segments of hatchery smolt releases and the Bear Lake smolt out-migration in 1978, comprised an estimated 15.2% to the sport catch. The total contribution of enhanced adult coho production, therefore, was 4,059 fish or 22.8% to the sport fishery.

Ad-CWT marked adult coho salmon survived from 91,775 age 1.0 (1976 brood, Seward Lagoon origin) hatchery smolts released in Seward Lagoon (39,189), Grouse Lake (25,430) and Bear Creek below the weir (27,156) in 1978. LV and RV marked coho were from 24,427 Bear Lake smolts marked at Bear Creek weir. Unmarked hatchery coho salmon resulted from 116,333 smolts (same brood year and origin) stocked in Seward Lagoon (86,790), Grouse Lake (28,125) and lower Bear Creek (1,418). Additional unmarked coho salmon survived from 73,232 Bear Lake smolts released unmarked past Bear Creek weir in 1978.

A total of 46,570 marked, age 1.0 (1977 brood, Bear Lake origin) hatchery coho smolts were stocked in Seward Lagoon (23,620 Ad-CWT), Grouse Lake (11,750 Ad-CWT) and lower Bear Creek (11,200 RV) in mid-May, 1979. An additional 135,670 unmarked, hatchery smolts (same brood year and origin) were released in Seward Lagoon (74,220), Grouse Lake (32,250) and lower Bear Creek (29,200) with the marked smolts.

These plants were comprised of considerably smaller smolts (15-18 g or 29-25/lb) compared to those made in 1978 (45 g or 10/lb). Age 1.1 marked (Ad-CWT and RV) and unmarked adults surviving from these smolt releases will return in 1980. The total sport fishing effort exerted for Resurrection Bay coho was an estimated 24,651 man-days. About 16% of the season's effort was sampled during the creel census period. The mean number and percentage of sport fishing boats returning daily to the Seward small boat harbor are shown in Table 11. The average number of anglers per boat was as follows: weekdays, 3.19; weekends, 3.11; and salmon derby, 3.22.

Table 10. Derby and Total Sport Harvest of Coho Salmon in Resurrection Bay,
1975-1979.

Year	Total Sport Harvest	Derby Harvest	% Derby Harvest
1975	19,793	3,799	19.2
1976	9,456	2,708	28.6
1977	16,345	6,007	36.8
1978	15,550	7,258	46.7
1979	17,785	6,073	34.1

Table 11. Mean Number and Percentage of Sport Fishing Boats Returning to the Seward Small Boat Harbor During Each Sampling Period, 1979.

Periods (hours)	Weekends		Weekdays	
	Mean No. of Boats	Percent	Mean No. of Boats	Percent
8:00 a.m. - 11:30 a.m.*	19.0	11.6	6.6	14.3
11:30 a.m. - 3:00 p.m.	37.7	23.0	11.3	24.5
3:00 p.m. - 6:30 p.m.	73.2	44.7	16.9	36.7
6:30 p.m. - 10:00 p.m.	<u>34.0</u>	<u>20.7</u>	<u>11.3</u>	<u>24.5</u>
Total	163.9	100.0	46.1	100.0

* Percentage for this period determined by three-year mean, 1964-1966.

Fishing effort and mean seasonal catch per hour are summarized for 1975-1979 in Table 12. The fishing effort was 7,679 man-days on weekdays and 8,692 on weekends, excluding the derby. Military personnel and dependents, fishing on boats provided by the Army and Air Force recreation camps at Seward, contributed 12.3% (3,029 man-days) to the total effort. Civilian anglers fishing on weekdays realized the highest coho salmon catch per hour (0.166), whereas the lowest catch rate (0.130) occurred during weekends when effort was more intense. The average numbers of hours anglers fished per day were as follows: weekdays, 4.98; weekends, 5.01; and salmon derby, 5.91.

An estimated 114 chinook salmon were harvested during the census period at an average rate of only 0.02 per boat. This is lowest abundance of chinook estimated in Resurrection Bay in 12 years. Two age 0.3 adults from the 1976 smolt release (25,100 LV marked) and one age 0.1 jack from the 1978 smolt plant in Box Canyon Creek (150,000, 25% Ad-CWT) were observed on August 8 in that tributary. Another age 0.1 jack was detected on September 1 during creel census. A total of 218,500 age 0.0 smolts (1978 brood, 50% Crooked Creek and 50% Ship Creek origins), marked 25% Ad-CWT per lot, were stocked during June 5-7, 1979 in Box Canyon Creek. This plant marks the last one for Box Canyon Creek due to the negligible returns realized from the previous three experimental chinook smolt releases in this stream. It was hoped that a natural chinook salmon run could be established to supplement the Resurrection Bay sport fishery.

The Resurrection Bay pink salmon harvest in 1979 (2,752 fish), nearly identical to the 1975 catch (2,659), was also atypically high for an odd-year run. Odd-year sport harvests have averaged 1,264 pink salmon from 1968-1978. As in 1975, the unusual abundance of this species was apparently the result of pink salmon stocks bound elsewhere. Resurrection Bay tributaries received their usual, sparse odd-year spawning escapements in 1979, according to foot surveys. Pink salmon were most abundant in the sport fishery from late July through early August when anglers averaged 1.10 fish per boat and 0.33 per man-day.

Adult Coho Timing and Abundance in Index Streams:

The peak of the 1979 index escapements ranged from late October through early November, and peak of spawning occurred within the following 2 weeks in these index streams. Estimated minimum escapements of wild coho salmon in each stream index area since 1975 are presented in Table 13.

The total combined index escapement of 337 wild adults is nearly identical to that of the 1976 parent brood escapement which mainly produced it, but approximately 20% lower than the abundance of the previous cycle's (1975-1978) mean. It is noted that the abnormally large Box Canyon Creek escapement (121 coho salmon) was responsible in maintaining an otherwise meager total index escapement in 1979.

Table 12. Derby and Total Sport Effort (Man-Days) Exerted for Coho Salmon and Mean Catch Per Hour in Resurrection Bay, 1975-1979.

Year	Period of Census	Total Effort	Derby Effort	% Derby Effort	Seasonal Catch Per Hour
1975	July 9 - Sept. 7	20,047	5,871	29.3	0.135
1976	July 8 - Sept. 12	19,681	8,421	42.8	0.084
1977	July 9 - Sept. 7	23,997	9,121	38.0	0.113
1978	July 8 - Sept. 10	22,291	10,064	45.1	0.126
1979	July 8 - Sept. 9	24,651	8,280	33.6	0.131

Bear Lake Upstream Migration:

The Bear Creek weir upstream migrant trap was operated continuously from May 10 through November 15. The first adult coho salmon entered the trap on August 11 and the last one was captured November 14. In contrast to the previous 2 years, only 20 coho salmon spawned in lower Bear Creek after the adult run had entered the trap, according to a foot survey on November 8.

A total of 2,493 adults and 23 jacks were enumerated from the trap. Abundance and timing of the adult coho salmon migration are shown in Table 14. Weekly breakdown by marked release lot is presented in Table 15.

The adult migration peaked (50%) on September 20, and the highest daily count of 160 (6.4% of the adult run) occurred on September 23. Mean stream temperatures at the beginning, peak and end of migration were 14.7°C (58.5°F), 10.8°C (51.5°F) and 2.8°C (37.0°F), respectively. Most of the migration (85.4%) occurred from September 2 through October 6 when Bear Creek temperatures ranged from 7.8°C to 12.8°C (46°F - 55°F) and flows, from 12 to 189 cfs.

Most (94.4%) of the marked coho salmon escapement to the weir returned from 27,156 Ad-CWT hatchery smolts released in lower Bear Creek in 1978. With the additional 1,016 and 81 estimated taken by the boat and beach harvests, respectively, plus eight strays observed in local escapement index streams, the total return from this marked lot was 1,276 fish. An estimated 67 unmarked adults also survived from 1,418 unmarked hatchery smolts released with the above marked smolt lot. Therefore, the total return from the 1978 lower Bear Creek smolt plant was estimated at 1,343 adults, or 4.7% smolt-to-adult survival, in 1979. Table 16 shows the various components comprising total adult returns of Bear Creek, Bear Lake, Grouse Lake and Seward Lagoon coho salmon production from 1978 smolt releases.

Only 43 LV/RV marked adult coho salmon were estimated surviving (0.2%) from 24,427 age 1.0, 2.0 and 3.0 Bear Lake smolts marked at Bear Creek weir in 1978. However, it has been noted previously that ventral fin regeneration does occur in smolts fin clipped at the weir (McHenry, 1979). Therefore, it is suspected that a substantial number of the unmarked Bear Lake adult escapement resulted from survival of the above marked smolts with subsequent fin regeneration.

An estimated 3,867 unmarked Bear Lake adult coho salmon survived from 73,232 smolts released unmarked past the weir in 1978. Total smolt-to-adult survival of this lot, therefore, was 5.3%. This survival was slightly higher (0.6%) than that estimated for the Ad-CWT lot, despite the size differential at release. Bear Lake smolts averaged 19.0 g (24/lb) compared to 45.0 g (10/lb) mean weight of Ad-CWT smolts released in Bear Creek in 1978.

Table 13. Minimum Wild Coho Salmon Escapement in Seven Index Streams in the Resurrection Bay Area, 1975-1979.

Name of Stream	Minimum Escapement					Mean 1975 to 1978
	1975	1976	1977	1978	1979	
Airport	2	24	7	14	1	12
Box Canyon	8	45	45	28	121	32
Clear	15	89	37	59	42	50
Dairy	32	17	134	146	68	82
Grouse	12	27	187	360	14	146
Jap	31	94	62	51	61	59
Mayor	<u>5</u>	<u>46</u>	<u>42</u>	<u>50</u>	<u>30</u>	<u>36</u>
Total	105	342	514	708	337	417

Table 14. Bear Lake Adult Coho Salmon Enumerated Through Bear Creek Weir by Weekly Periods, 1979.

Weekly Periods	Marked	Unmarked*	Male	Female	Total
Aug. 5 - 11		1	1		1
Aug. 12 - 18		2	1	1	2
Aug. 19 - 25		51	32	19	51
Aug. 26 - Sept. 1	1	77	58	20	78
Sept. 2 - 8	13	231	166	78	244
Sept. 9 - 15	42	494	315	221	536
Sept. 16 - 22	43	522	362	203	565
Sept. 23 - 29	37	462	267	232	499
Sept. 30 - Oct. 6	37	247	172	112	284
Oct. 7 - 13	36	102	76	62	138
Oct. 14 - 20	6	46	25	27	52
Oct. 21 - 27	1	2	1	2	3
Oct. 28 - Nov. 3	15	16	15	16	31
Nov. 4 - 10	3	5	8		8
Nov. 11 - 17	—	<u>1</u>	—	<u>1</u>	<u>1</u>
Total	234	2,259	1,499	994	2,493

* Seventy-five percent of the 1978 smolt out-migration were released unmarked to enhance smolt-to-adult survival.

Table 15. Marked Adult Coho Salmon Enumerated Through Bear Creek Weir by Weekly Periods, 1979.

Weekly Periods	Marked (Fin-clip)*			Total
	Ad-CWT	RV	LV	
Aug. 26 - Sept. 1	1			1
Sept. 2 - 8	11	1	1	13
Sept. 9 - 15	38	4		42
Sept. 16 - 22	40	3		43
Sept. 23 - 29	35	1	1	37
Sept. 30 - Oct. 6	37			37
Oct. 7 - 13	36			36
Oct. 14 - 20	6			6
Oct. 21 - 27	1			1
Oct. 28 - Nov. 3	14	1		15
Nov. 4 - 11	<u>2</u>	<u>—</u>	<u>1</u>	<u>3</u>
Total	221	10	3	234

* Ad-CWT (adipose - coded wire tag) - 1978 Bear Creek smolt release.
 LV (left ventral) - 1978 Bear Lake smolts marked (25%) at weir.
 RV (right ventral)- 1978 Bear Lake smolts marked (25%) at weir.

Table 16. Estimated Adult Return Components of Bear Lake, Bear Creek, Grouse Lake and Seward Lagoon Enhanced Coho Salmon Production from 1978 Smolt Releases.

Water Body and Fin Mark	Boat Harvest*	Beach Harvest**	Escapement	Strays*	Total Return	Smolt-to-Adult Survival (%)
Bear Creek						
Ad-CWT	1,016	31	221	8	1,276	4.7
UNM	42	14	11		67	4.7
Bear Lake***						
LV,RV	18	10	13	2	43	0.2
UNM	1,619	...	2,248		3,867	5.3
Grouse Lake						
Ad-CWT	193	6	42	1	242	1.0
UNM	462	48	49		559	2.0
Seward Lagoon						
Ad-CWT	133	106	29		268	0.7
UNM	<u>576</u>	<u>175</u>	<u>61</u>	<u>—</u>	<u>812</u>	<u>0.9</u>
Total						
Marked	1,360	153	305	11	1,829	2.0
UNM	2,699	237	2,369		5,305	2.8

* Boat harvests and strays of Ad-CWT coho salmon were apportioned according to relative abundance of Ad-CWT escapements estimated in each system. Boat harvests of unmarked (UNM) hatchery coho salmon were apportioned according to UNM escapements estimated by Ad-CWT smolt-to-adult survivals per system. Total boat harvest of UNM hatchery coho salmon was estimated by 3.02:1 catch: escapement ratio determined for Ad-CWT returns.

** Beach harvests of Bear Creek and Grouse Lake hatchery coho salmon were estimated proportional to their respective escapements after apportioning 74% (1973-1978 average) of the total beach harvest to the Seward Lagoon return.

*** Boat harvest of unmarked Bear Lake coho salmon was estimated by applying the 0.72:1 catch: escapement ratio of marked (LV, RV) Bear Lake fish to the UNM Bear Lake escapement. Contribution of UNM Bear Lake coho salmon to the beach fishery was unknown but believed to be small.

Although it is recognized that some of the unmarked Bear Creek coho salmon probably resulted from natural smolt production in lower Bear Creek, the vast majority of these adults are believed to have survived from the aforementioned Bear Lake smolt release.

Mean fork length and weight of adult coho salmon sampled at the weir are presented in Table 17. The male:female sex ratio, excluding jacks, was 1.5:1 in the Bear Creek escapement.

The 23 unmarked jack coho salmon enumerated from the trap resulted both from 94,014 unmarked Bear Lake smolts and 29,200 age 1.0 (1977 brood, Bear Lake origin) hatchery smolts released unmarked in Bear Creek in 1979. Size difference of smolts between the two lots was slight: Bear Lake smolts averaged 19.5 g (23/lb) compared to 18.2 g (25/lb) mean weight for the hatchery smolts. It has been observed (McHenry, 1979) that smolt plants consisting of larger smolts (e.g. 10/lb) tend to produce higher jack returns than releases comprised of smaller fish.

Coho Salmon Egg-Takes:

Although sufficient fish returned to the weir to satisfy the Department's coho salmon egg requirements for the Southcentral region's needs (1.9 million), over 70% of those held died before ripening. A total of 228 males and 649 females were held in the Bear Creek holding facility from September 1 to November 13. Stream temperatures ranged from 1.7°C to 13.3°C (35°F - 56°F), and flows from 12 to an estimated 233 cfs during this period. Male and female holding mortalities were 75.9% and 70.3%, respectively. It is believed that Bear Creek's excessive stream flows during the peak upstream migration period resulted in coho salmon arriving in poor condition and subsequently dying from fungus, Saprolegnia sp., disease before attaining sexual maturity.

Though the Seward Lagoon trapping and holding facility was not considered operational until October 31, the total estimated coho salmon escapement into the lagoon (160 adults) was too small to compensate for the above high holding losses. Nevertheless, a total of 13 males and 18 females were electroshocked and dipnetted from First Lake outlet, tributary to Seward Lagoon, and transported to Bear Creek weir for eventual artificial spawning. Only one adult was captured from the lagoon trap.

A total of 190 females and 40 males were artificially spawned, yielding an estimated 730,800 eggs. Mean fecundity was 3,846 eggs per female, compared to 4,397 in 1978 when females averaged 0.11 kg (0.24 lb) less than 1979 females. Eggs were fertilized at an average ratio of 1 male:5 females. Dead egg loss after shocking at Fort Richardson Hatchery averaged 6.2% (Wall, personal communication). All spawned carcasses were deposited in Bear Lake for natural fertilization.

Table 17. Mean Fork Length (mm) and Weight (kg) of Adult Coho Salmon Sampled at Bear Creek Weir in 1979.

Lot	Males			Females			Sexes Combined		
	No.	FL	Wt.	No.	FL	Wt.	No.	FL	Wt.
Ad-CWT	9	684.8	3.95	7	673.1	3.88	16	679.7	3.92
LV	2	642.0	3.24				2	642.0	3.24
RV	1	638	3.81				1	638	3.81
UNM	<u>168</u>	<u>669.3</u>	<u>3.75</u>	<u>141</u>	<u>667.9</u>	<u>3.88</u>	<u>309</u>	<u>668.7</u>	<u>3.81</u>
Total	180	669.6	3.76	148	668.2	3.88	328	668.9	3.81

Other Species:

Only 18 sockeye salmon ascended Bear Creek to the weir in 1979. Twelve were two-or three-ocean adults and six were one-ocean jacks. Three-ocean adults were expected to return from 5,654 smolts which emigrated Bear Lake in 1976, two-ocean adults from 855 smolts in 1977, and one-ocean jacks from 11,952 smolts in 1978. The factors responsible for such poor smolt-to-adult survival are unknown, but may be related to an electrical ground problem experienced in lower Bear Creek in 1977. The electrical field precluded adult sockeye from migrating to the weir that year, and may have been sufficiently severe since 1976 to cause high smolt mortalities in lower Bear Creek (McHenry, 1978). Sources of the electrical ground problem were repaired in the fall of 1977.

The first pink salmon entered the trap on July 25, and the few that returned eventually spawned in lower Bear Creek during the last half of August. Upstream migrating Dolly Varden ascended Bear Creek to the weir beginning on June 21, and continued moving in and out of the trap throughout the remaining field season.

All fish species other than sockeye or coho salmon were retained below the weir.

Enhanced Coho Salmon Production:

Fin marked (Ad-CWT) coho salmon spawning escapements bound for Seward Lagoon, Grouse and Bear Creeks were estimated at 135, 49, and 260 adults, respectively. An additional 25 LV/RV coho salmon were estimated in the Bear Lake escapement. Also, unmarked coho salmon escapements attributed to unmarked segments of the Seward Lagoon, Grouse Lake and Bear Creek hatchery smolt releases in 1978 were 236, 97, and 25 adults, respectively. These escapements include observed strays and coho salmon estimated taken in the shore fishery after the Resurrection Bay sport trolling effort terminated (Table 16).

Overall smolt-to-adult survival of marked and unmarked Bear Lake smolts was 4.0%. Total smolt survival for Seward Lagoon coho salmon, including 147 immatures and jacks estimated in 1978, was only 0.98%. The extreme stocking rate of 5,000 smolts per hectare (12,351/acre) in the 4.13 ha Seward Lagoon may have overcome a maximum density threshold, thereby severely limiting smolt survival prior to their emigrating the lagoon. With the estimated 153 immature coho salmon in 1978, total smolt survival of the Bear Creek smolt release was 5.24%. Total smolt survival of the Grouse Lake smolt plant, including 118 immatures estimated in 1978, was just 1.72%. The reason for this relatively low survival is unknown in view of previous Grouse Lake returns, but is not believed to be related to overstocking. Summaries of total survivals for Bear Lake, Seward Lagoon, Bear Creek and Grouse Lake smolt releases are presented in Tables 18, 19, 20 and 21, respectively.

Table 18. Survival of Bear Lake Coho Salmon Adults from Seaward Migrations of Smolts Fin Marked at Bear Creek Weir, 1973-1978.

Seaward Migration Year	Number of Smolts Released	Age Composition of Out-Migration	Mean Fork Length (mm)	Fin-clip Used	Number of Adults Returning*	Percentage Return
1973	76,652	100.0% - age 1.0	107.5	Ad	5,040	6.58
1974	62,698	88.6% - age 1.0	117.8	Ad	1,762	2.49
	8,067	11.4% - age 2.0	147.6	Ad		
	<u>70,765</u>					
1975	11,532	8.0% - age 1.0	107.3	Ad	1,603	1.12
	131,180	91.4% - age 2.0	129.2	Ad		
	877	0.6% - age 3.0	150.7	Ad		
	<u>143,589</u>					
1976	63,674	68.7% - age 1.0	106.3	Ad-RV	2,674	2.88
	28,031	30.2% - age 2.0	134.9	Ad-RV		
	1,010	1.1% - age 3.0	161.0	Ad-RV		
	<u>92,715</u>					
1977**	49,689	49.8% - age 1.0	113.1	Ad-LV	3,835	3.84
	48,332	48.4% - age 2.0	129.5	Ad-LV		
	1,684	1.7% - age 3.0	182.8	Ad-LV		
	139	0.1% - age 4.0	192.0	Ad-LV		
	<u>99,844</u>					
1978**	80,886	82.8% - age 1.0	120.0	LV,RV	3,910	4.00
	16,431	16.8% - age 2.0	134.8	LV,RV		
	342	0.4% - age 3.0	191.7	LV,RV		
	<u>97,659</u>					

* Includes boat and shore sport harvest estimates.

** Marked only 25.0% of out-migration.

Table 19. A Summary of Hatchery Reared Coho Salmon Smolt Releases in Seward Lagoon.

Brood Year	Origin	Mark	Smolt Liberation Data			Adult Return Data				Total Number	Return Percent
			Release Date	Number	Fish/kg(lb)	0+ Ocean(jacks) No.	%	1-Ocean No.	%		
1966	Oregon	Ad	4/18-22/68	42,200	40.1 (18.2)	0	0.00	15	0.04	15	0.04
1967	Oregon	Ad	5/6-7/69	27,100	32.2 (14.6)	1	0.00	6	0.02	7	0.03
1968	Bear Lake	Ad	5/19-27/70	39,750	23.8 (10.8)	952	2.39	5,114	12.87	6,066	15.26
1969	Bear Lake	Ad	5/17/71	10,900	31.3 (14.2)	3	0.03	1,519	13.94	1,522	13.96
1970	Kodiak	Ad	5/31/72	66,500	37.0 (16.8)	915	1.38	2,963	4.46	3,878	5.83
1971	Seward Lagoon	Ad-LV	5/7-9/73	30,200	19.6 (8.9)	140	0.46	125	0.41	265	0.88
1972	Kodiak	Ad-RV	5/6-11/74	100,000	20.7 (9.4)	4,764	4.76	3,885	3.89	8,649	8.65
1973	Seward Lagoon	Ad-LV	5/15-19/75	100,700	20.1 (9.1)	2,610	2.59	1,971	1.96	4,581	4.55
1974	Bear Lake	LV	5/4-10/76	100,600	28.2 (12.8)	600	0.60	4,513	4.49	5,113	5.08
1975	Bear lake	RV	5/6-13/77	100,450	27.7 (10.3)	1,622	1.61	7,710	7.68	9,332	9.29
1976	Seward Lagoon	Ad-CWT**	6/1-5/78	125,979	21.7 (9.9)	147	0.12	1,080	0.86	1,227	0.98

* Includes boat and shore sport harvest estimates.

** Release consisted of 27,052 smolts (51.5% marked) from Ship Creek Hatchery and 98,927 smolts (26.0% marked) from Fort Richardson Hatchery.

Table 20. A Summary of Hatchery Reared Coho Salmon Smolt Releases in Lower Bear Creek.

Brood Year	Origin	Smolt Liberation Data				Adult Return Data*				Total Number	Return Percent
		Mark	Release Date	Number	Fish/kg(1b)	0+ Ocean(jacks)		1-Ocean			
						No.	%	No.	%		
1967	Oregon	Ad	5/8-13/69	47,470	30.4 (13.8)	8	0.02	17	0.04	25	0.05
1968	Bear Lake	Ad	5/27/70	6,400	22.7 (10.3)	76	1.19	285	4.45	361	5.64
1969	Bear Lake	Ad	5/18-21/71	51,100	31.3 (14.2)	14	0.03	178	0.35	192	0.38
1970	Kodiak	Ad	5/15-24/72	155,500	32.6 (14.8)	155	0.10	470	0.30	625	0.40
1974	Bear Lake	Ad-LV	5/12-14/76	35,600	25.1 (11.4)	16	0.05	756	2.12	772	2.17
1975	Bear Lake	Ad-RV	5/13-15/77	35,100	23.1 (10.5)	436	1.24	1,709	4.87	2,145	6.11
1976	Seward Lagoon	Ad-CWT**	5/31/78	28,574	22.2 (10.0)	153	0.54	1,343	4.70	1,496	5.24

* Includes boat and shore sport harvest estimates.

** A total of 1,418 smolts (5.0%) were unmarked.

Table 21. A Summary of Hatchery Reared Coho Salmon Smolt Releases in Grouse Lake.

Brood Year	Origin	Smolt Liberation Data				Adult Return Data*				Total Number	Return Percent
		Mark	Release Date	Number	Fish/kg(1b)	0+ Ocean(jacks)		1-Ocean			
						No.	%	No.	%		
1974	Bear Lake	RV	5/10-12/76	35,200	26.8 (12.2)	50	0.14	1,498	4.26	1,548	4.40
1975	Bear Lake	LV	5/15-17/77	35,100	22.3 (10.1)	446	1.27	2,304	6.56	2,750	7.83
1976	Seward Lagoon	Ad-CWT**	5/30/78	53,555	24.9 (11.3)	118	0.22	801	1.50	919	1.72

* Includes boat and shore sport harvest estimates.

** A total of 25,430 smolts (47.5%) were marked, 28,125 (52.5%) were unmarked.

DISCUSSION

Since 1976, Bear Lake has been stocked annually at approximately 1,250 instead of formerly (1972-1975) 2,500 coho fingerlings per hectare with the following results: (1) Though Bear Lake has averaged about 17,000 fewer smolts per year (1977-1979) at the reduced stocking density, fingerling-to-smolt survival has increased 66% over the previous (1973-1976) smolt production period; (2) The percentage of fingerling releases resulting in yearling (age 1.0) smolts has increased 40% since 1975, with yearling smolt-to-fingerling biomass (kg) ratios similarly rising from 0.4:1 to 5.9:1 in that time span; (3) Healthier, more robust smolts in 1977-1978 (condition factor $K=1.01$) averaged 36% higher smolt-to-adult survival than their earlier counterparts with $K=0.97$. Therefore, barring further egg shortages, the current Bear Lake stocking density will be maintained until findings indicate that it should be readjusted for increased smolt production in the future.

At present, Bear Lake's optimum smolt production level under natural conditions appears to be approximately 100,000 smolts with $K=1.01$ for a total biomass of 2,100 kg. It may be possible to increase Bear Lake's carrying capacity of juvenile coho salmon via artificial fertilization of its rearing environment. However, additional knowledge of Bear Lake's limnological parameters and their interrelationships with critical trophic levels may be required prior to actual application of inorganic fertilizer.

In conjunction with the Department's Fisheries Rehabilitation, Enhancement and Development (F.R.E.D.) Division, baseline research data are currently being acquired on Bear Lake's water chemistry, primary productivity levels, benthic communities, and zooplankton populations during the growing season. Once Bear Lake's nutrient and plankton cycles are better understood, experimenting with artificial fertilization and subsequent fingerling stocking rates may logically proceed toward evaluation.

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